A Knowledge-Based Approach to Facilitate Queries by Hajj Pilgrims

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Abstract

Hajj pilgrims need to undergo a proper and comprehensive training before leaving their mother countries in order to perform a successful and rewarding hajj. Despite of being trained, the pilgrims might not be aware of some rules and regulations that may affect their hajj rituals or rites if the pilgrims do not follow them. They may have many queries pertaining to hajj rituals, which cannot be found in their guidebooks. They could have the queries while doing any of the rituals in the middle of the crowded areas and might need to call the experts to solve the queries. However if they cannot contact the experts at the moment, they might not be able to find the solution immediately. We propose a question and answer (Q&A) expert system using a knowledge-based approach to facilitate queries by the hajj pilgrims either before or while performing their hajj rituals. We have developed the research prototype on a Web-based application, which we suggest to be installed on kiosks located around Mecca or Madinah or in handheld devices. This paper covers the theoretical aspects of knowledge-based approach to facilitate queries by hajj pilgrims. We also discuss some basic examples of how the approach can be realized in a hajj Q&A system as a personalized e-hajj guidebook.

1. Introduction

Hajj pilgrims need to be trained and equipped with hajj knowledge before going to Mecca. Although they have undergone the training at their respective mother countries, they might have other queries regarding rules and regulations (*hukum* or *fatwa*) while performing hajj and probably the queries cannot be found in the hajj guidebook. A printed guidebook with proper table of contents and indexes may be helpful. However doing extensive search of solutions to the specified problems manually could be a daunting task and time consuming. There are possibilities that they need to solve the problems or queries regarding the hajj rituals, the rules and regulations immediately. In this case, the pilgrims will encounter difficulties if the solutions cannot be found in the guidebook and no experts are around them.

Knowledge-based expert systems have been used to support queries in many areas or problem domains including power system [1], petrography or study of rock samples [2], and search engines [3][4][5][6]. We believe such expert systems can facilitate questions and answers very well for hajj ritual queries. Knowledge of experts should be retained extensively in the system to solve all possible queries. The knowledge-based repository should be dynamic so that the data can be updated from time to time once new expert's knowledge pertaining to certain queries is added to the system. The problems can be categorized based on genders (female, male) and Muslim groups (*mazhab* or *maslak*) including Hanafi, Shafai, Maliki, Hambali, Salafi and Shia. By having this classification, the problems can be more specific and the solutions can be generated to the users faster. In addition, such system should be more generic to cater the needs of diverse Muslims groups or *mazhab* around the world.

By using a knowledge-based approach, the expert system enables related problems to be answered and possible solutions are listed to the pilgrims for their reference promptly. The approach requires an inference engine that can draw conclusions based on the facts

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given by the hajj pilgrims. Such expert system can also be benefited during the hajj training in their respective mother countries to equip them with rules and regulations in hajj rituals before leaving for Mecca. Thus the Training, Education and Awareness (TEA) research group of USM Hajj Research Cluster has proposed the research work that will be discussed in this paper.

In the following sections we will explain the proposed knowledge-based approach to facilitate question and answer (Q&A), examples of the approach using a prototype system, related work, finally conclusion and future work.

2. Knowledge-based approach for hajj Q&A

The study of knowledge is concerned with nature, structure and origins of the knowledge. In a knowledge-based system, knowledge acquisition is very important. It is one of the two main components in the system. The knowledge is divided into three categories that are procedural knowledge: often referred as knowledge that has sequence steps, declarative knowledge: knowledge that knowing something is true or false and tacit knowledge: cannot be expressed by language like 'how to move hand' [7]. In this research, the knowledge concerned is procedural and declarative categories.

The other component in knowledge-based system is inference engine. Users state their problems via the interface, the inference engine draw the conclusions after examining the knowledge base. These conclusions are responses of the system to users' queries. The system makes inference in the same way that a human expert would infer the solution of a problem. That is by giving some facts; a conclusion that follows is inferred. In this system we need experts to produce a set of rules. Thus a user-friendly interface is vital for such system, as the experts must not be the system developers. This ensures dynamic inputs from the experts in the hajj domain.

There are two methods of inference: forward chaining that derive conclusion from facts and backward chaining that does the process in a reverse way. We use forward chaining in this research in which the users or pilgrims provide the facts such as their genders, *mazhab*, their eligibility, type of hajj they perform, and status or position of their hajj rituals done. Three main categories of queries can be inferred:

- General questions about hajj or umrah.
- Before performing hajj: eligibility to perform hajj.
- While performing hajj: the status of their hajj rituals.

All the three types of queries can be used in the learning process of hajj pilgrims who use such system while undergoing hajj training in their mother countries.

The methods to represent the knowledge in an expert system include [7]:

- Rules: Easy to implement, ordering of the rules is important.
- Semantic net: Provide a simple, economical, and relatively intuitive representation form, similar to the function of human information storage. Semantic networks are easy to implement and to manipulate due to its flexibility. Related knowledge is easily clustered. It only deals with small pieces of knowledge. However facts placed inappropriately may cause problems.
- Frames: Easier to understand; allow unrestrained alteration or cancellation of slots. Any slot can be changed hence the properties a frame inherits can be altered or cancelled anywhere in the hierarchy.

In the proposed knowledge-based approach, we have chosen to use rules method to represent the knowledge of hajj rituals because it is more suitable to state rules and regulations of hajj rites in the Q&A system to be inferred by the inference engine when hajj pilgrims make queries. By using a knowledge-based approach in the expert system (refer Figure 1) the rules can be retained in the hajj knowledge base and then users who are the hajj pilgrims can input their queries via the user interface of the system. The possible solutions or answers will be prompted to the users by the inference engine. Advanced search utility is also a crucial feature in an expert system in order to retrieve the knowledge queried to provide the solutions to the problems using the search engine. In this paper we limit the discussion on inference engine rather than search engine.

The main research question is: *How to facilitate queries by hajj pilgrims more effectively?* The null hypothesis to be rejected is H_o*: A knowledge-based approach for Q&A system does not significantly improve the understanding of hajj rituals by the pilgrims*. The validation of the work in the future will be applying the method suggested in [8]. For the scope of this paper, we do not include the evaluation to test the hypothesis.

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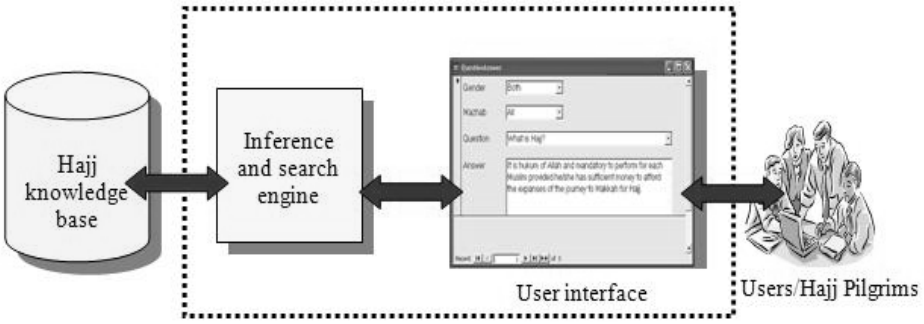

Figure 1. Knowledge-based approach in the proposed hajj Q&A expert system

The language of *if-then* rules or *production* rules is the most popular formalism to represent knowledge in an expert system. The conditional statements used can have various interpretations as below [9]:

- *if* precondition P *then* conclusion C;
- *if* situation S *then* action A;
- *if* condition C1 and C2 hold *then* condition C does not hold.

The diverse interpretations above correspond to the nature of queries or problems in hajj rites, which the examples will be given in the next section. In order to explain further the knowledge-based approach for the proposed system: Let R is the set of rules determined by the experts based on the knowledge of rules and regulations in hajj and its rites. Let Q is the set of queries made by the hajj pilgrims or users. Let A be the set of answers produced by the inference engine based on the queries. For instance, given Q_1 of set Q to the system, the inference engine will use forward chaining of reasoning the relevant rules R_1, R_2, R_3… of set R in order to generate the possible subset of answer A.

3. Examples of Q&A

In this section we will discuss some examples of how an expert system can increase the understanding of hajj rites learned by the pilgrims with an efficient use of knowledge-based approach. By Q&A mechanism, the learning curve of beginners in hajj domain probably can be reduced as they can learn different scenarios in hajj rituals by providing different questions and learn from the possible answers inferred by the inference engine.

As mentioned in Section 1 of the introduction, the hajj rites problems can be classified into two main cases: The first case, all the commandments of Allah are in such a way that they fall under and addressed to three categories: all or both males and females, males only or females only. In the second case, a Muslim is bound to obey the commandments of Allah but according to the *sunnah*, the way of prophet Mohammad (s.a.w). In addition, there is a variation in *sunnah*. Many actions done by prophet Mohammad (s.a.w) are contradictory and a person cannot follow them simultaneously. He or she can follow only one way at a time. The standardization of the *sunnah* is done by many *Ulemas* (theological experts) that ended up into at least six big groups of followers (five of *sunni* and *shia*). The *sunni* include Shafai, Hanafi, Hambali, Maliki, Ahle-Hadith or Salafi. It will depend upon the person that he or she opts which of these *maslaks* or *mazahibs*. However in countries such as Malaysia, the Muslim citizens are required to follow Shafai group.

Problems related to all categories of problems (general knowledge about hajj and *umrah*, eligibility to perform hajj and issues in hajj rituals) can be classified into the category of the person in terms of gender as well as *mazhab*. The type of hajj to be performed is also crucial when the approach used to answer the problems related to hajj rituals. There are three types of hajj: *tamatuk*, *ifrad*, and *qiran*. Hence in an expert system there should be a provision for all possible combination of classification of the person who asks questions. A simple procedure is to tag each possible question from the experts with the above three classification codes in a three-tuple format as in Figure2. By having the classification, the inference of the knowledge base can be done faster and more efficient. To ensure personalization of users, the system must be able to retain details of the users. Thus when users login to the system, the page simulates a personalized e-hajj guidebook that recognizes the owners every time they login into the system. However, putting such systems in kiosks around Mecca and Madinah require further consideration of some pertaining issues such as Internet access and its bandwidth. This includes the issue of installing such system in handheld devices that probably appropriate for simple problems that involve minimal texts. The issues will not be discussed in details in this paper.

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First tuple: Gender of the person	Second tuple: *Mazhab* of the person	Third tuple: Type of hajj

Figure 2. The three-tuple format to represent the classification of pilgrims

Based on the three-tuple format we can code each possibility of combination of questions based on classification. Let the first tuple T_1 of gender can have the values of 0:both male and female, 1:male, 2:female. Let the second tuple T_2 of *mazhab* can be 0:all, 1:Shafai, 2:Hanafi, 3:Hambali, 4:Maliki, 5:Salafi, 6:Shia. Let the third tuple T_3 for type of hajj with the values of 0:all, 1:*tamatuk*, 2:*ifrad*, 3:*qiran*. Thus each question Q_i and answer A_i can be tagged to each combination of classification.

3.1. General or open queries

General questions cover general information about regulations or *hukum* in Islam with focus in performing hajj and *umrah*. We give three examples of problems with their corresponding tuple values T_1, T_2, and T_3 that involve different classification of pilgrims as the followings:

- **Example 1: Tuple: 000**

Q_1: What is Hajj?
A_1: It is *hukum* of Allah and mandatory to perform for each Muslim provided he or she has sufficient money to afford the expenses of the journey to Mecca for Hajj.

- **Example 2: Tuple: 010**

Q_2: What is *Farz* in *Wudhu*?
A_2: *Farz* in *Wudhu*: (1) Washing of both hands up to elbows, (2) Washing of face ear to ear and hair of fore head to below chin, (3) *Masah* (spread wet hand up to ¾ hair of head), (4) washing of both feet up to ankles.

- **Example 3: Tuple: 020**

Q_2: What is *Farz* in *Wudhu*?
A_3: *Farz* in *Wudhu*: (1) Intention, (2) Washing of both hands up to elbows, (3) Washing of face ear to ear and hair of fore head to below chin, (4) *Masah* (spread wet hand up to ¾ hair of head), (5) washing of both feet up to ankles, (6) follow the order 1 to 5.

The first example of query Q_1 is meant for all or both male and female, and for all *mazhab*. The answer A_1 will be the same if the gender is female and the *mazhab* is Maliki for instance. The same answer A_1 will be returned to other combination of status to this query Q_1. Example 2 and 3 show different subset of answers A_2 and A_3 that are generated when the same question Q_2: is queried for different *mazhab* (Hanafi and Shafai) of all genders. The complexity of the expert system will increase as the number of different status is considered for each related question. At the beginning, we will focus a number of queries that cover different cases to test the inference engine of the expert system.

The three examples given before are specific questions with specific answers. It is also possible to allow users who are not sure of their *mazhab* to indicate their mother countries and the system should be able to relate the countries with the associated *mazhab*.

3.2. Queries on eligibility to perform hajj

However, some problems could be very complex and they are also inter-related to each other. For example the problems related to eligibility of a woman who wants to perform the hajj without a husband due to some reasons related to the husband. This problem requires the expert system to infer a number of related rules. It requires a multi-level interface compared to that of direct problems as previously discussed. Figure 3 shows the example of interface to check the eligibility of pilgrims to perform hajj. In this example, the pilgrims will understand what are the rules that they should fulfill before they are eligible to perform hajj. They can check different scenarios of eligibility either for themselves or for other hajj pilgrims. Currently the prototype system is in Malay language.

Different *mazhab* has different *fatwa* regarding women performing hajj. A female pilgrim should be accompanied by her husband or a person unmarriageable to her, for Ibn ‘Abbas (may Allah be pleased with the son and his father) said: I heard Allah’s Messenger (peace be upon him) saying, “A female pilgrim should not travel except in the company of her husband or a person unmarriageable to her.” A man stood and said, “O Messenger of Allah! My wife is going to perform Hajj while I have listed myself among those who will participate in a battle.” He replied, “Go and perform Hajj with your wife”.

The Hanafis and Hanbalis have held that a female pilgrim should be accompanied by her husband or a person unmarriageable to her. The Shafai have held that she may be accompanied by her husband, a person unmarriageable to her or by pious and upright women; and some said that only one pious and upright woman is enough [10].

The Malikis maintained that she could go in the company of a trustworthy group if she could reach Mecca in no more than a full day. If a woman performs hajj alone without her husband or a relative unmarriageable to her, her hajj is valid but she shall bear the sin of not abiding by the commands of hajj. These conditions are only required in the obligatory Hajj [10].

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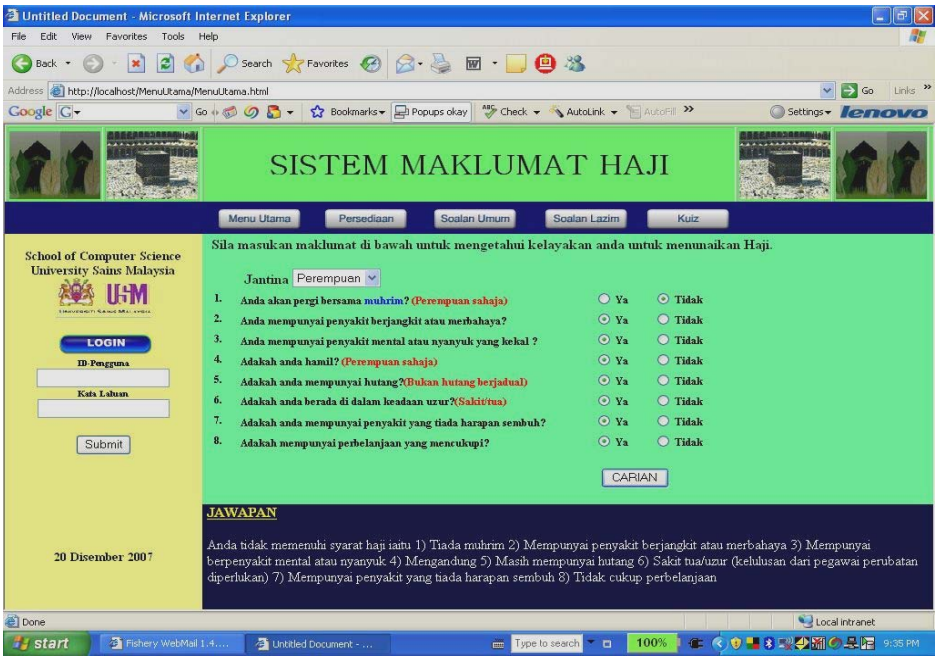

Figure 3. An example of interface to check the eligibility of the pilgrim to perform hajj

A set of examples of such problem is derived and listed as below [11]:

- Performing hajj without the husband's permission.
- Husband does not keep his promise to perform hajj with the wife.
- Husband sells alcohols and pork and uses the income to support the wife's hajj expenses.
- Husband is busy and cannot accompany the wife who has no other *mahram*.

In the first problem, if the woman has a *mahram* (a person unmarriageable to her) and has fulfilled the conditions to perform an obligatory hajj (*fardu*) she can go without getting her husband's permission. The husband has no right to forbid his wife from performing the obligatory hajj. However if it is a voluntarily hajj (*sunat*) or a repetition, it is mandatory for her not to go.

In the second related problem, the woman can perform a *fardu* hajj if the husband has broken his promise provided that she has other *mahram* to accompany her. In this case the husband should keep the promise that is made after their *akad* (official contract of marriage following the stated conditions in Islam). If the promise is made before the *akad*, the solution is not stated clearly by Soleh Al-Munajid *et al*. [11] but breaking the promise is a criterion of a *Munafik* person. Hence it is mandatory for the husband to fulfill his promise as long as it does not cause any dreadful consequences to the husband.

However if the woman has fulfilled the conditions to perform the hajj and she has a *mahram* to accompany her, but the money she has raised to perform the hajj is from the husband who sells alcohols and pork, she cannot perform hajj using the money and she is considered as a person who cannot afford to perform hajj. For the last problem, if the woman has no other *mahram* besides her husband, it is *haram* (a sin) to perform hajj without a *mahram*. Thus she cannot go and must wait until her husband is free to accompany her.

By using the *if-then* rules to represent the knowledge, the conditional statements with different interpretations are as below:

- Related to precondition and conclusion:
  if she can afford R_1 *then* she can perform hajj S_1;
- Related to situation and action:
  if she does not get her husband's permission for *fardu* hajj R_2 *then* she can perform hajj S_1;
  if she does not get her husband's permission for *sunat* hajj R_3 *then* she cannot perform hajj $\sim S_1$;
  if the husband does not keep his promise R_4 *then* she can perform hajj S_1;
- Related to conditions hold and condition does not hold:
  if she is not debt free $\sim R_5$ *and* she is not healthy $\sim R_6$ *and* she has no transport $\sim R_7$ *and* she has no money $\sim R_8$ *and* she has no assets to support the

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left family members $\sim R_9$ *and* she has no *mahram* to accompany her $\sim R_{10}$ *then* she cannot afford $\sim R_1$.
if her husband is busy R_{11} *and* she has no *mahram* to accompany her R_{10} *then* she cannot afford $\sim R_1$.
if she has money R_8 *and* the money is given by the husband who sells alcohols and pork R_{12} *then* she cannot afford $\sim R_1$.

The sequences and order of the rules are crucial to ensure the sub rules are satisfied before the main rules are fulfilled in order to draw the conclusions. Users' interventions are also required in order to determine whether they satisfy the sub-rules before generating the conclusion.

3.3. Queries on hajj rituals

Another possible hajj problems are very much related to the practical aspects that occur while performing hajj rituals. Pilgrims who encounter such problems sometimes do not realize that they have done the mistakes and they can be penalized that requires them to pay the *dam*.

The flow chart in Figure 4 shows the sequence of inputs required before inferering the possible answers from the hajj knowledge base. Once the inference engine has found the possible answers, they will be generated and output to the users.

We give an example of how to apply *if-then* rules to represent the knowledge. For the problems related to hajj rituals, the conditional statements related to situation and action will be more suitable.

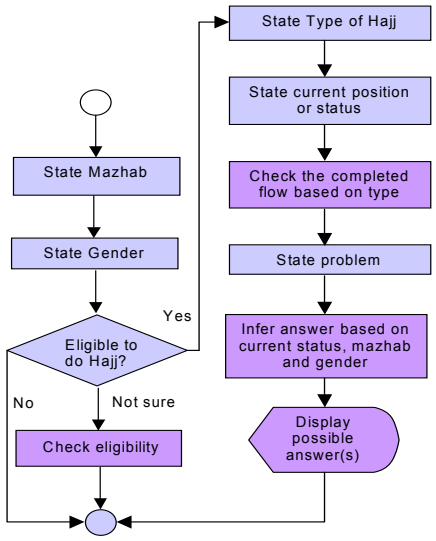

Figure 4. A flow chart illustrates how to solve layered problems in hajj ritual

The problem involves a woman who is doing hajj of type *tamatuk*.

- *if* she is having her menstruation R_1. *then* she can take *sunnah* shower S_1 and wear the *ihram* S_2 but she cannot pray $\sim S_3$.
- *if* she is not having her menstruation $\sim R_1$. *then* she can take *sunnah* shower S_1 and wear the *ihram* S_2 and she can pray S_3.
- *if* she has said the intention (*niat*) to perform umrah R_2 but not at the *miqat* (dedicated point) $\sim R_3$, *then* she has to go back to *miqat* S_4 or she can do it where she is now but with *dam* (penalty) S_5 and she is in the forbidden of *ihram* S_6.
- *if* she has said the intention (*niat*) to perform umrah R_2 and at the *miqat* (dedicated point) R_3, *then* she is in the forbidden of *ihram* S_6.
- *if* she has not said the intention (*niat*) to perform umrah $\sim R_2$ *then* she is not in the forbidden of *ihram* $\sim S_6$ or umrah not fulfilled S_7.
- *if* she has said *tarbiyah* R_4 but not at the *miqat* (dedicated point) $\sim R_5$, *then* she has to go back to *miqat* S_8 or she can do it where she is now but with *dam* (penalty) S_9.
- *if* she has said *tarbiyah* R_4 and at the *miqat* (dedicated point) R_5, *then* she is in the forbidden of *ihram* S_6.
- *if* she has not said *tarbiyah* $\sim R_4$ or is not sure saying *tarbiyah* R_6 but not at the *miqat* (dedicated point) $\sim R_5$, *then* she has to go back to *miqat* S_8 or she can do it where she is now but with *dam* (penalty) S_9.
- *if* she is having her menstruation R_6. *then* she cannot do *tawaf qudum* $\sim S_{10}$.
- *if* she is not having her menstruation $\sim R_6$ and she has done *tawaf qudum* R_7 *then* she can perform *sunnah* prayer S_{11}.
- *if* she is not having her menstruation $\sim R_1$ but she has not done *tawaf qudum* $\sim R_7$ *then* she must do *tawaf qudum* S_{10} and umrah not fulfilled S_7.

The set of rules must be continuously defined until the whole process of *tamatuk* hajj that include *saei*, *tahallul*, wearing *ihram*, hajj *niat*, stay overnight at Mina, *wukuf* at Arafah, stay overnight at Muzdalifah, until the end.

4. Related work

As we discussed earlier in the introduction section, a knowledge-based approach can be employed in an expert system in order to facilitate queries in various problem domains. Hence this has motivated us to

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propose a knowledge-based approach to support Q&A pertaining to hajj rituals.

Referring to the main research question indicated earlier: *How to facilitate queries by hajj pilgrims more effectively?* The main issues to be considered include what aspects to be concerned in order to provide an expert system that can improve the understanding of hajj knowledge by the pilgrims with the support of the proposed Q&A expert system. The level of understanding can be measured in terms of how much the Q&A system can assist users to improve their knowledge in hajj rites including their rules and regulations.

Based on the literature study conducted so far, there is no work specifically focuses on the use of knowledge-based approach to support queries in hajj issues. However there are a number of web sites and applications that provide general Q&A regarding Islam including hajj and *umrah* fatwa [12] as listed in Figure 5. We focus on the features provided by the system with no intention to verify the truth of the content, which is not within the scope.

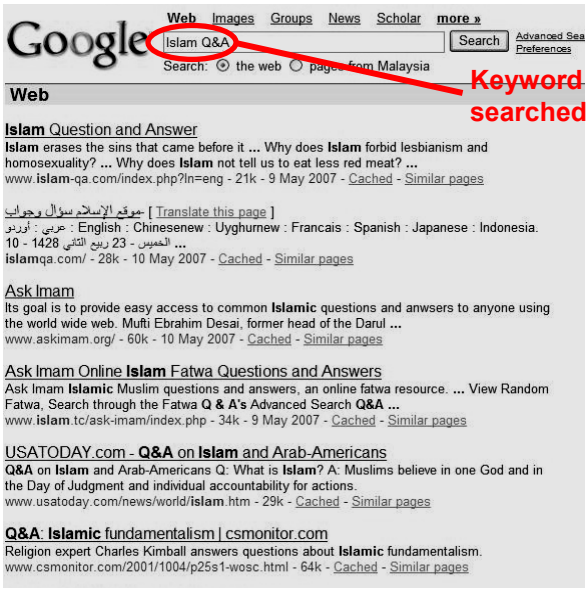

Figure 5. A list of related web sites that provide Islam Q&A and hajj fatwa [12]

Most systems provide the search utility to find a particular topic or problem queried. Besides, registered users are able to post their questions and then dedicated experts will provide the answers to the queries [10][13][14]. Refer Figure 6 and 7 for the screen shots.

The systems also allow any questions to be queried but they do not check duplication of questions instead they request users to make a search to ensure their queries do not exist before posting any new questions. Some systems such as in Islam Q&A [13] provide quite extensive search utilities that require users to set certain criteria of the questions or keywords searched including filtering options.

Generally such web-based systems are very useful to public users who would like to know about Islam in general and then make queries for certain topics they want such as hajj. However we need a system that is fully dedicated for hajj pilgrims. The system should support pilgrims during the training at their mother countries to further equip their knowledge in hajj rites and also to be used as an e-hajj guidebook embedded in handheld devices that can be used anytime, anywhere and anybody besides kiosks. This motivates us to propose this work.

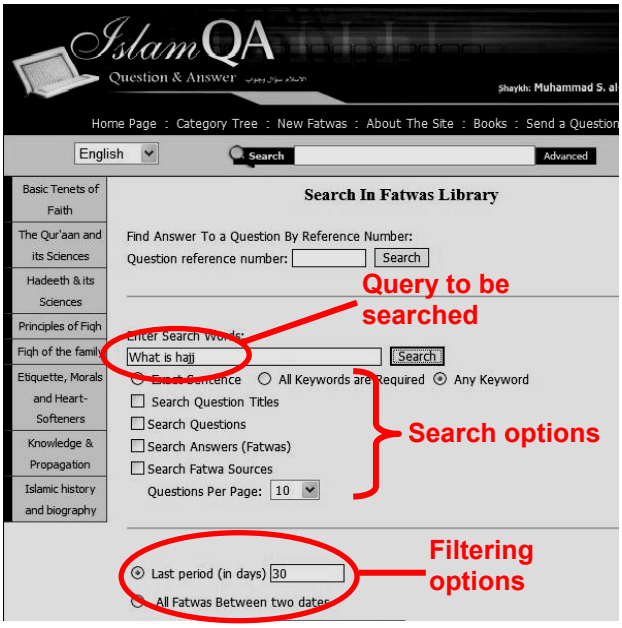

Figure 6. An advanced search utility provided by an Islam Q&A web site [13]

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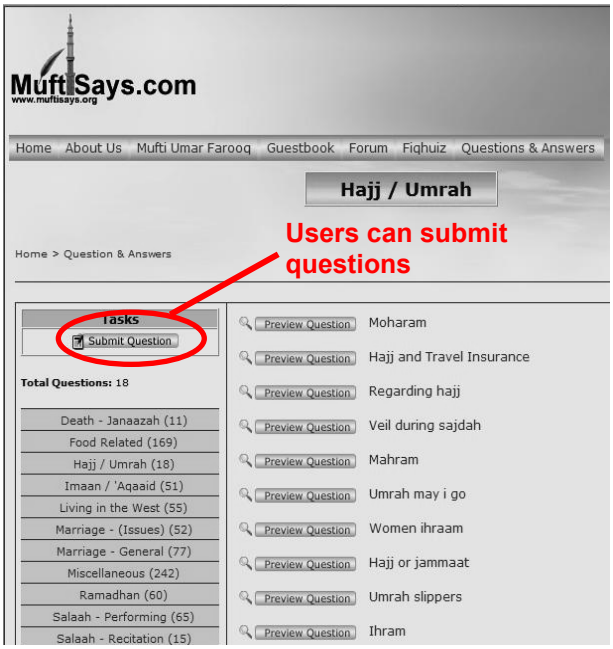

Figure 7. A web site displays the list of Q&A relasted to hajj and *umrah* [14]

5. Conclusion and future work

We have proposed a knowledge-based approach in an expert system to facilitate Q&A of hajj rites for pilgrims. The examples of how simple queries can be made by the gender and *mazhab* are shown. Besides examples of complex or multilayers queries that need users' intervention can also be made to solve inter-related problems regarding hajj.

Our future work will be to further improve the proposed approach in the prototype system that can be installed in kiosks located in Masjidil Haram or Madinah besides handheld devices. The consideration of different languages and levels of hajj pilgrims: the young, the less fortunate, the non-technology savvy and the old pilgrims are also crucial. We will extensively update the knowledge of experts into the knowledge base by completing the answers for Shafai group followed by other groups. It is also necessary to consider a suitable design of interface for the experts to update the knowledge base since the experts might not be the system developers. This is quite challenging especially to ensure the user interface is friendly enough to retrieve all related rules corresponding to certain sets of Q&A. Then we need to further evaluate the significance of the proposed approach to improve the understanding of hajj and its rituals by the pilgrims who use the system either during the training they undergo in their mother countries or while performing their hajj. The first evaluation should be among Malaysian hajj group who follow Shafai *mazhab*. The system is anticipated to be a personalized e-hajj guidebook that promotes the practice of learning and understanding hajj rites via Q&A, *insya-Allah*.

6. Acknowledgement

We would like to specifically acknowledge the Training, Education and Awareness (TEA) research group of USM Hajj Research Cluster in particular Prof. Mohd Omar Ab. Kadir, the former leader of TEA group. Generally, we also convey our gratitude to Hajj Research Cluster, USM and UQU (Umm Al-Qura University) to initiate the research collaboration. In addition we thank our postgraduates, Aisyah Ismail and Halimah Mohamed who had worked on the initial version of the prototype. May our research is blessed by Allah (s.w.t.).

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